Chromospheric Magnetic Field of Solar Active Regions

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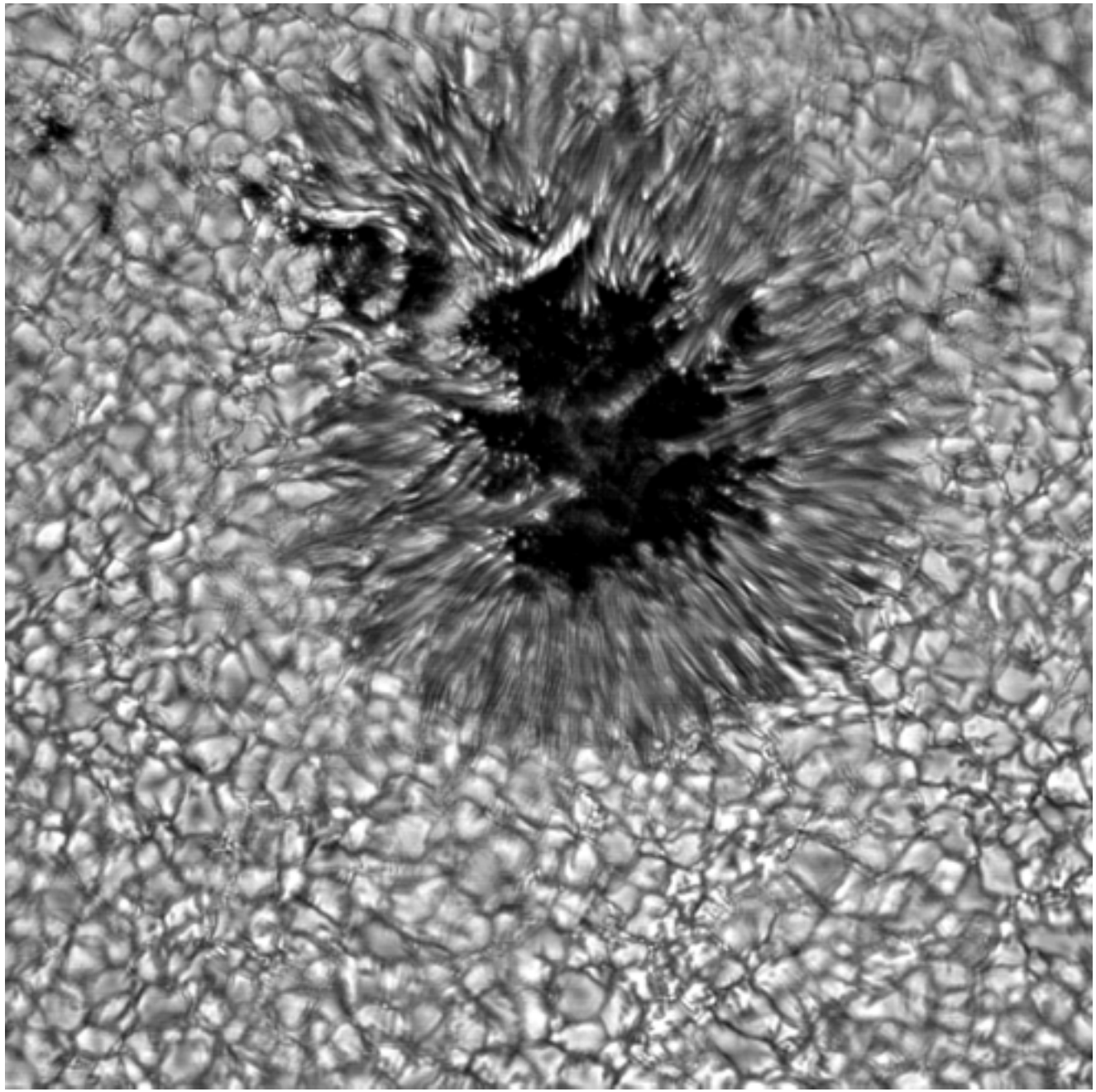
Motivation

- Most of the observed features on the solar atmosphere are governed by the Magnetic field.
- Energy transport from photosphere is through chromosphere.
- Magnetic Structure of Transition Region.
- The mechanism responsible for the stability and decay process of the active regions (Sunspots), which are the main ingredients of solar cycle, are not understood.
- At present, the reliable magnetic field observations are possible only at Photosphere, as the (1) signal at higher atmosphere is less, (2) the lines are broad, (3) inferring the field from polarization signal is difficult.



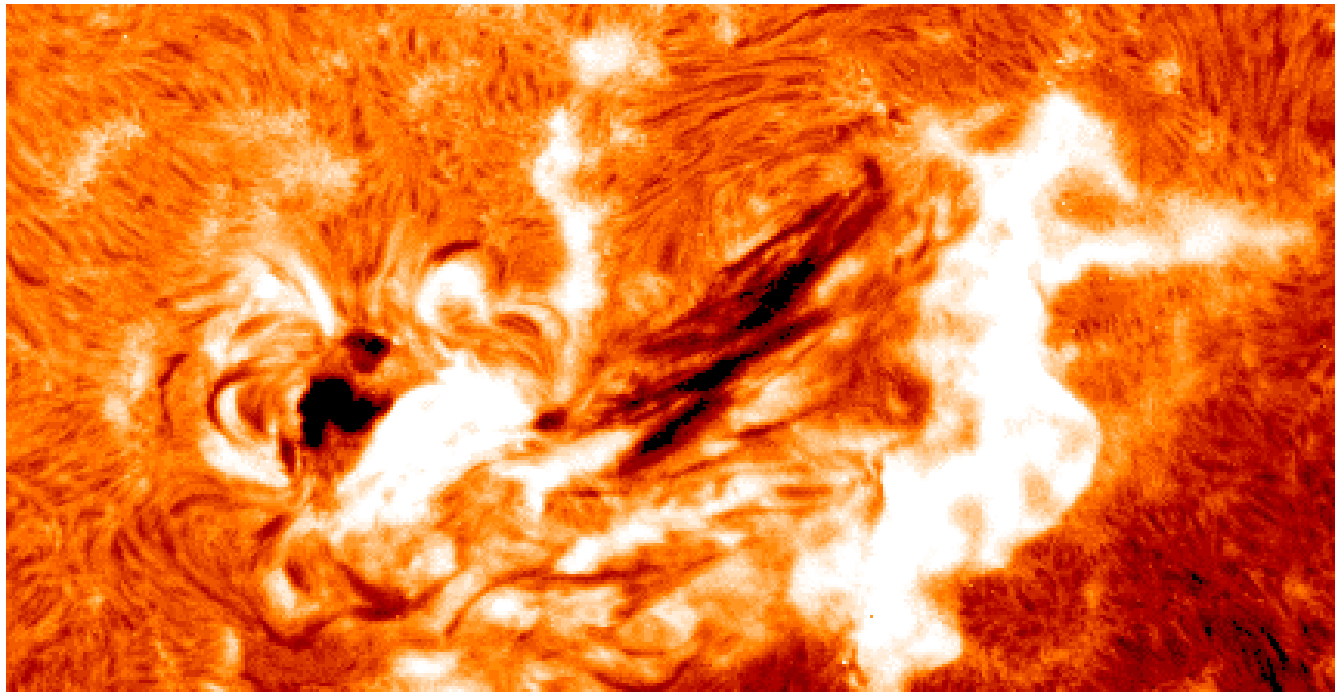
Debi prasad, C. and Gary, A., 1999, Sol. Phy.

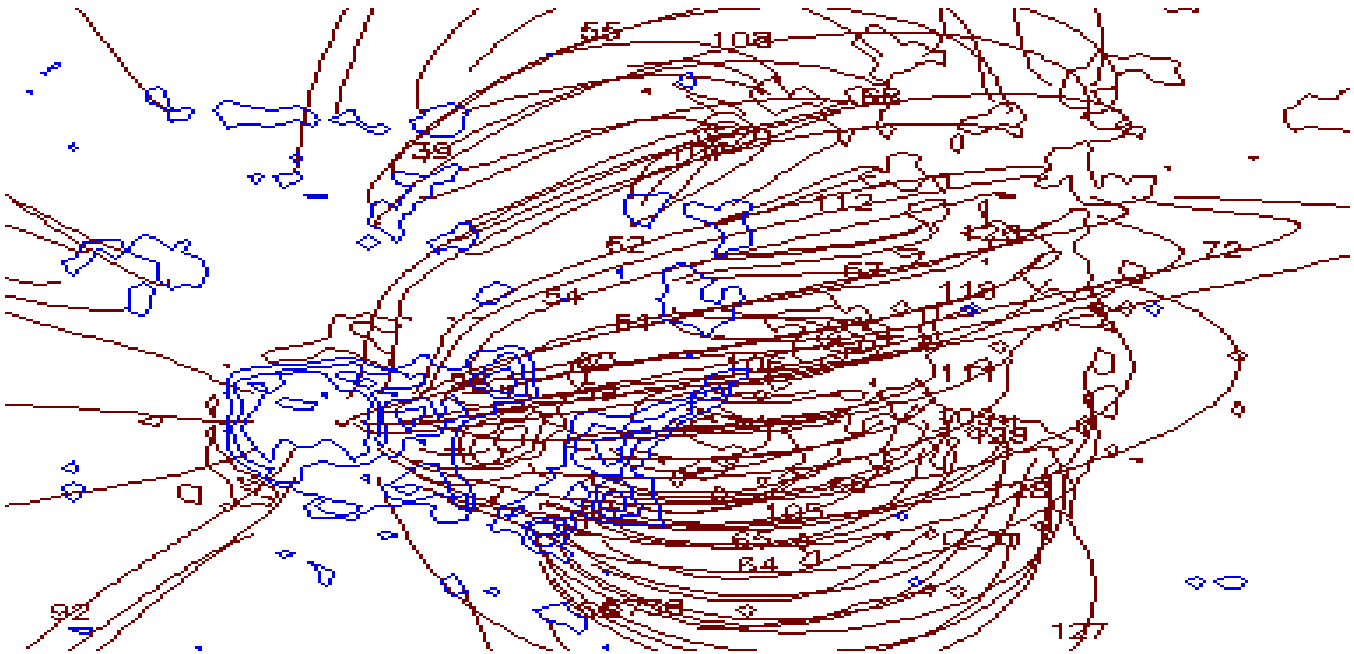
NOAA 6555

Hα

And

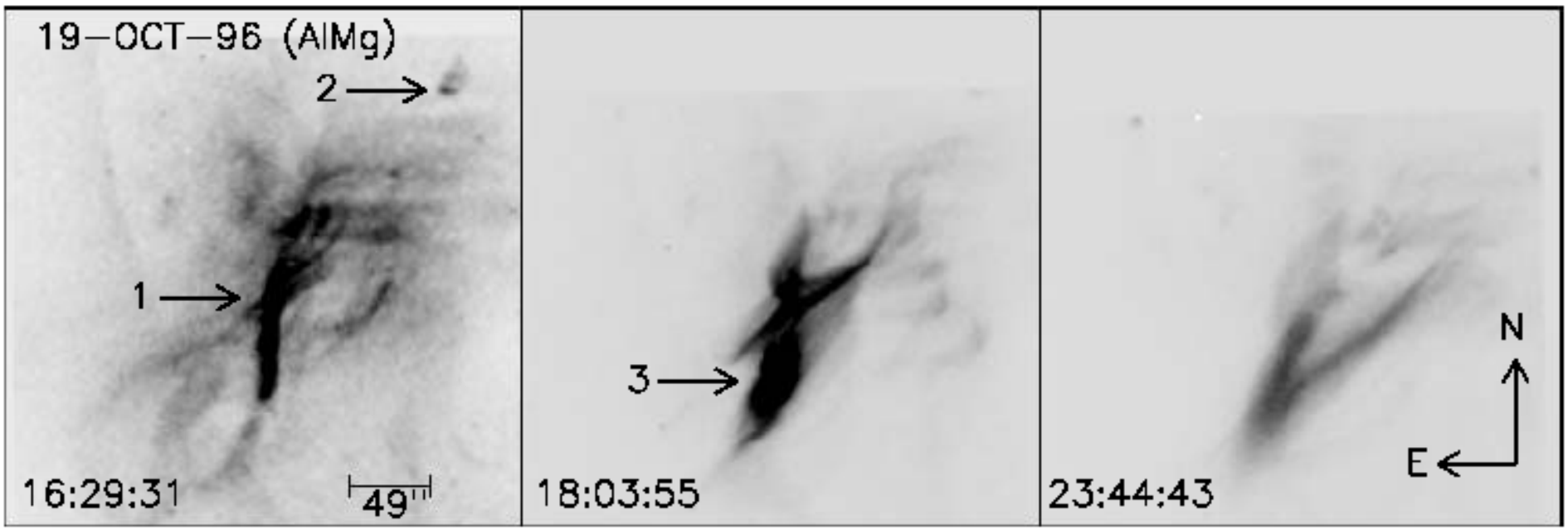
potential field extrapolation



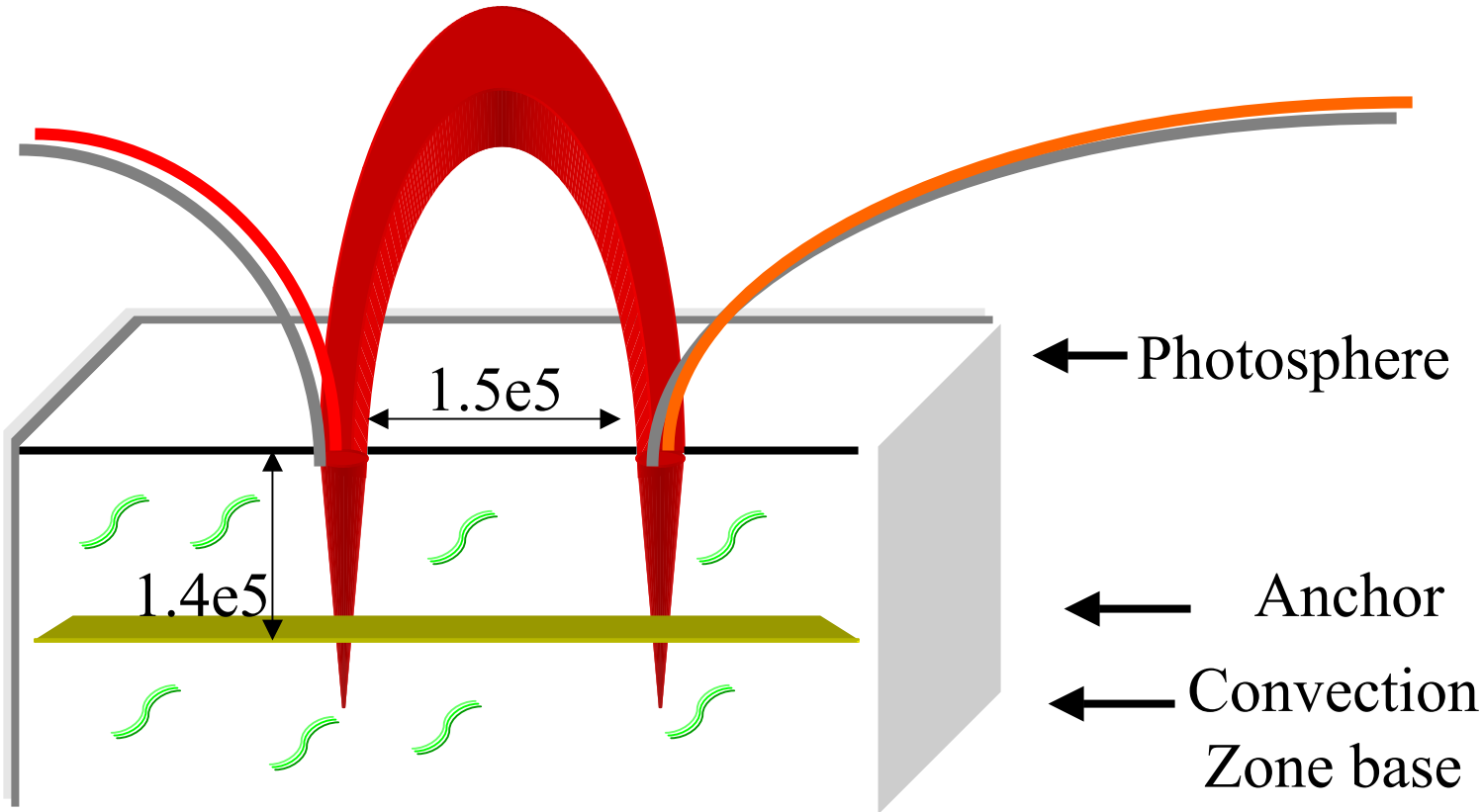


Debi Prasad et al., A&A, 394, 257 (2002)

Complex magnetic structure before a CME



Active Region

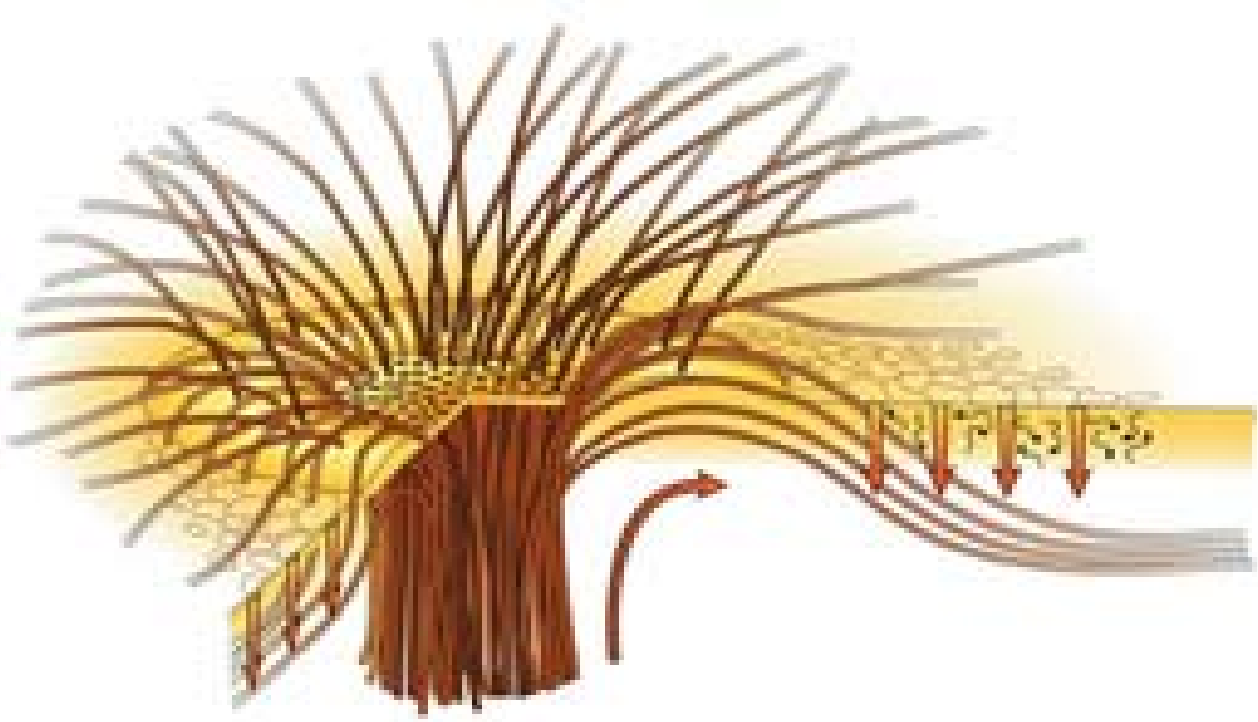


Active Regions

(Known from Photospheric Observations)

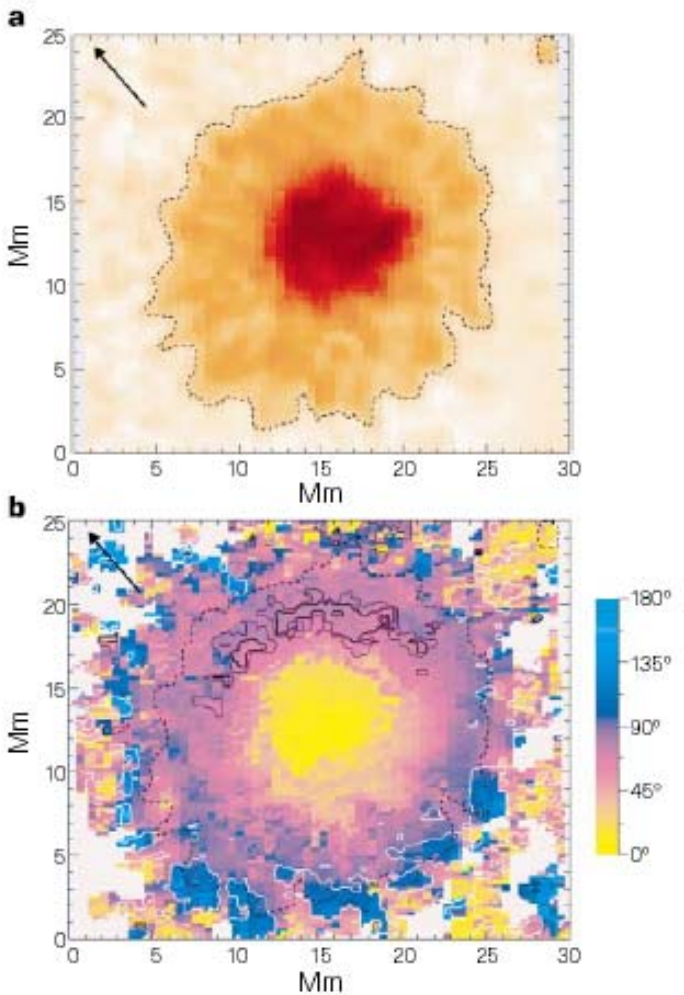
- **Size: <1000 km to ~10000 km**
- **Magnetic Field: ~ 3000 G**
- **Temperature: ~ 1/5th photosphere (Cool)**
- **Formed in hours to days.**
- **Live for weeks to months.**
- **They are of simple bi-pole to complex structures.**

What happens above Photosphere?

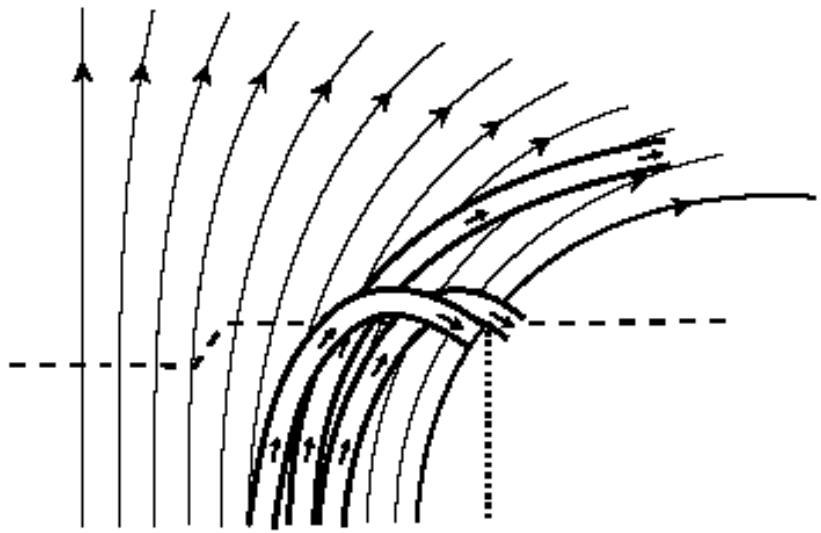


Thomas, et al., Nature, 420, 390 (2002)

Westendorp, et al., Nature, 389, 48 (1997)



~ 100 to 200 km



Giovanelli and Jones, Sol. Phy., 97, 267 (1982)

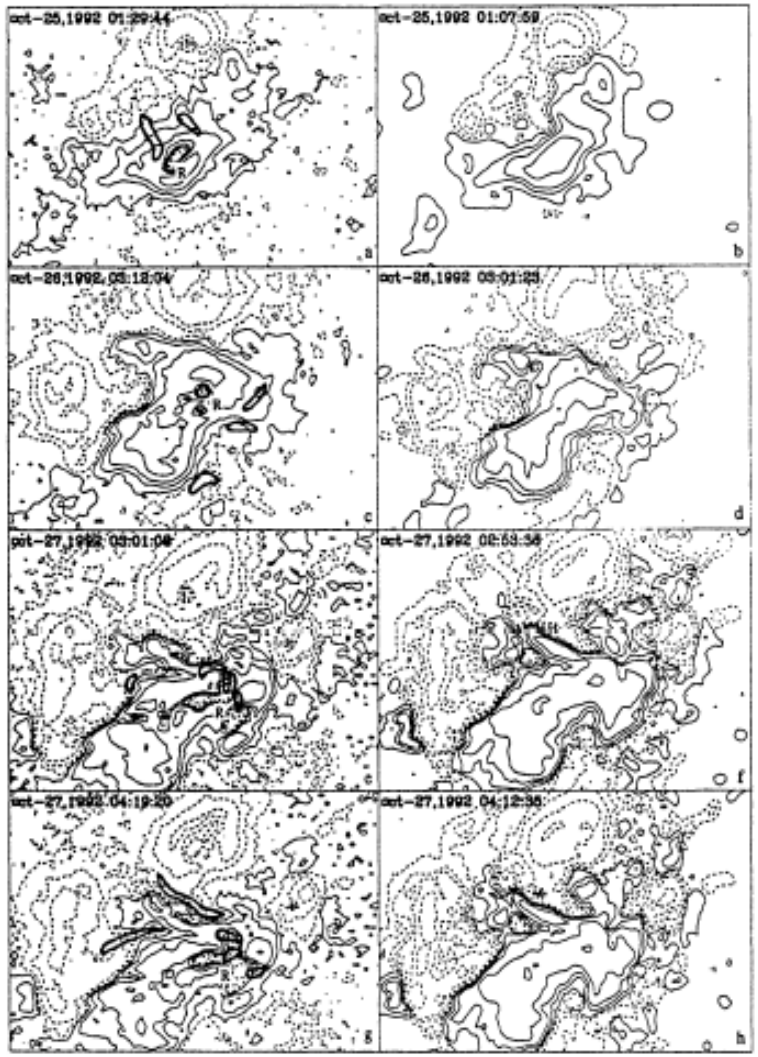
- Magnetograms of two active regions are obtained in C I 9111, Fe I 8688, Ca II 8542 Å and Hα lines.
- The field is strong and sharp in photosphere and weak and diffused in chromosphere.
- Canopy height of 150 to 700 km are derived.

Dara, Koutchmy and Alissandrakis, 277, 648 (1993)

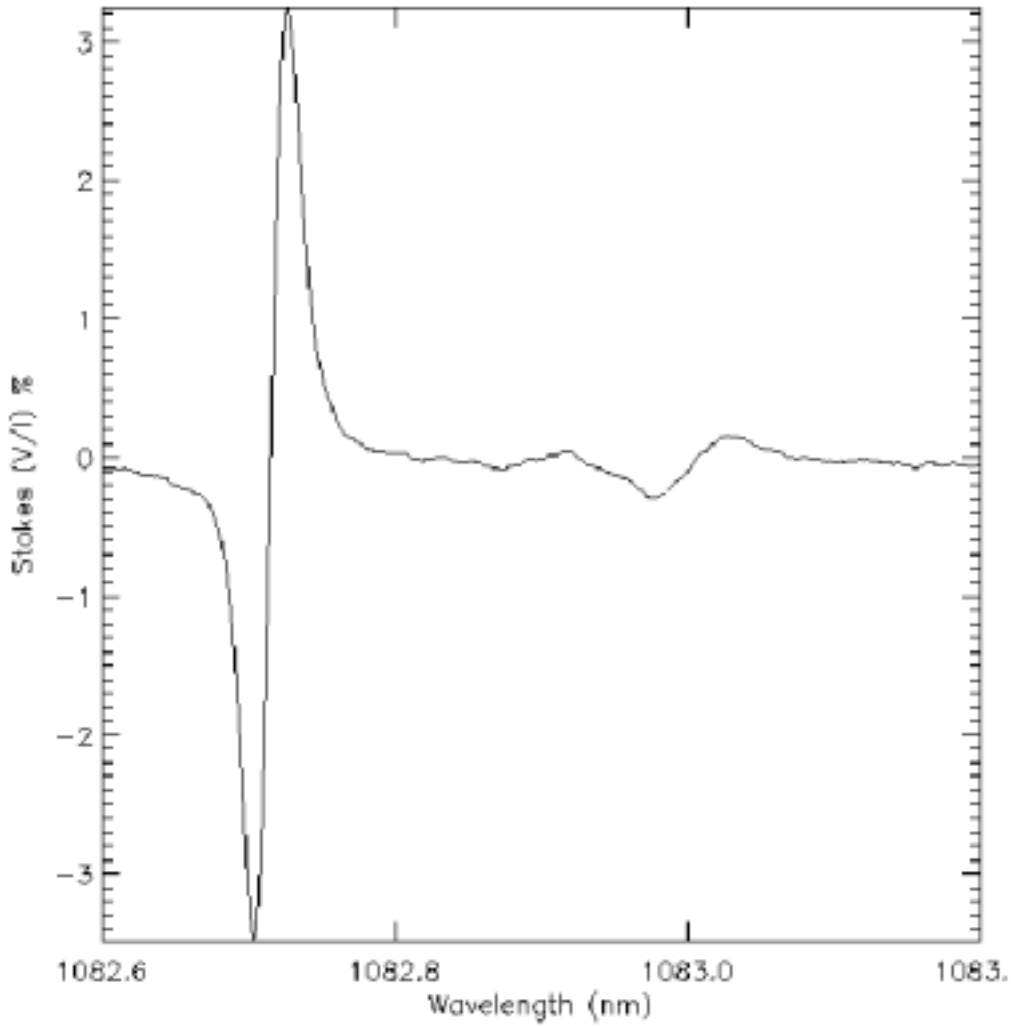
- High Resolution Magnetograms of a large split spot and opposite polarity pore in CaI 6102.7 Å and Hα lines.
- Spot unipolar in photosphere – opposite polarity in Chromosphere.
- No trace of Pore.
- The magnetic field configuration is not consistent with the constant-α model.
- Near superpenumbra the field is filamentary structured.

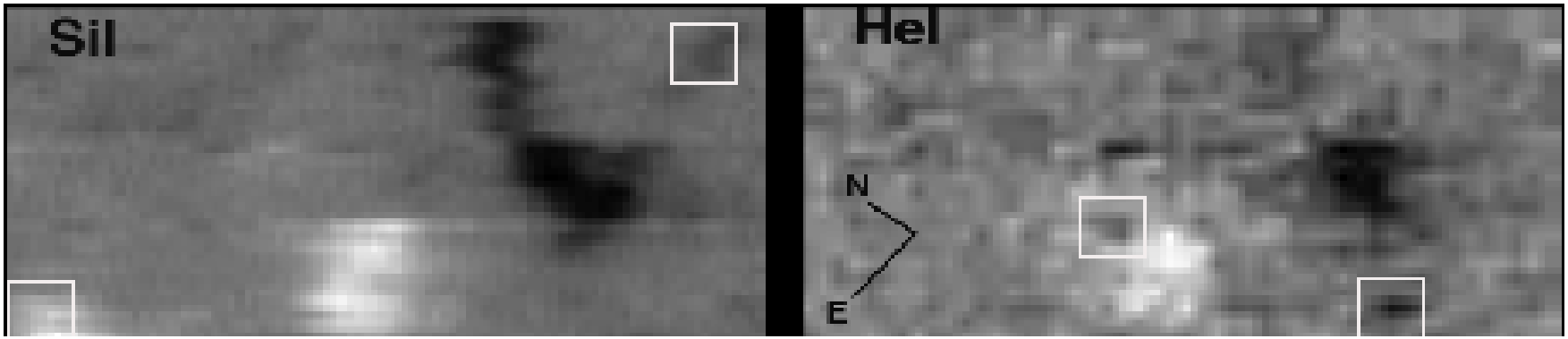
Liu, Y., Srivastava, N., Debi Prasad C., Li, We and Ai, G., Sol. Phy., 158, 249 (1995)

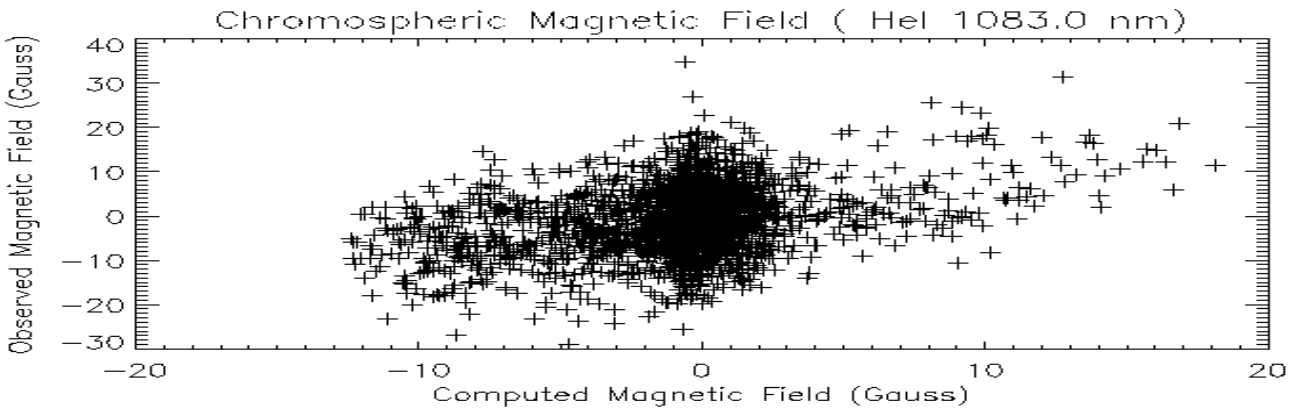
- Reversed polarity structure in chromospheric magnetgram compared to photospheric field.
- This may be due to the twisting of the flux tubes at it expands upward.

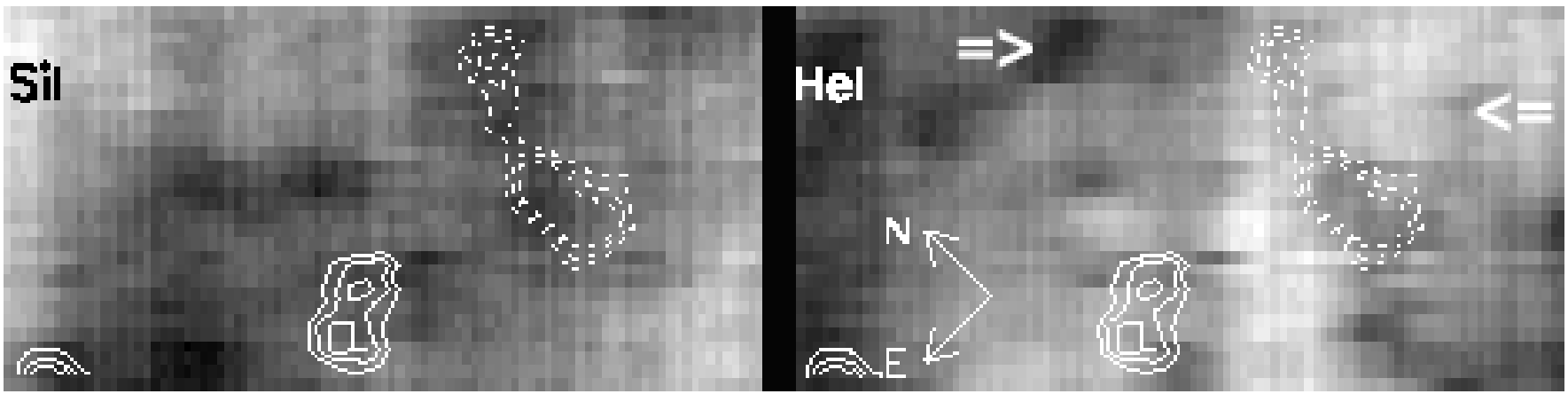


Debi Prasad C., Suematsu and Ichimoto, Sol. Phy., 209, 349 (2002)




SiI
HeI
N
E


Chromospheric Magnetic Field (HeI 1083.0 nm)
Observed Magnetic Field (Gauss)
40
30
20
10
0
−10
−20
−30
−20
−10
0
10
20
Computed Magnetic Field (Gauss)

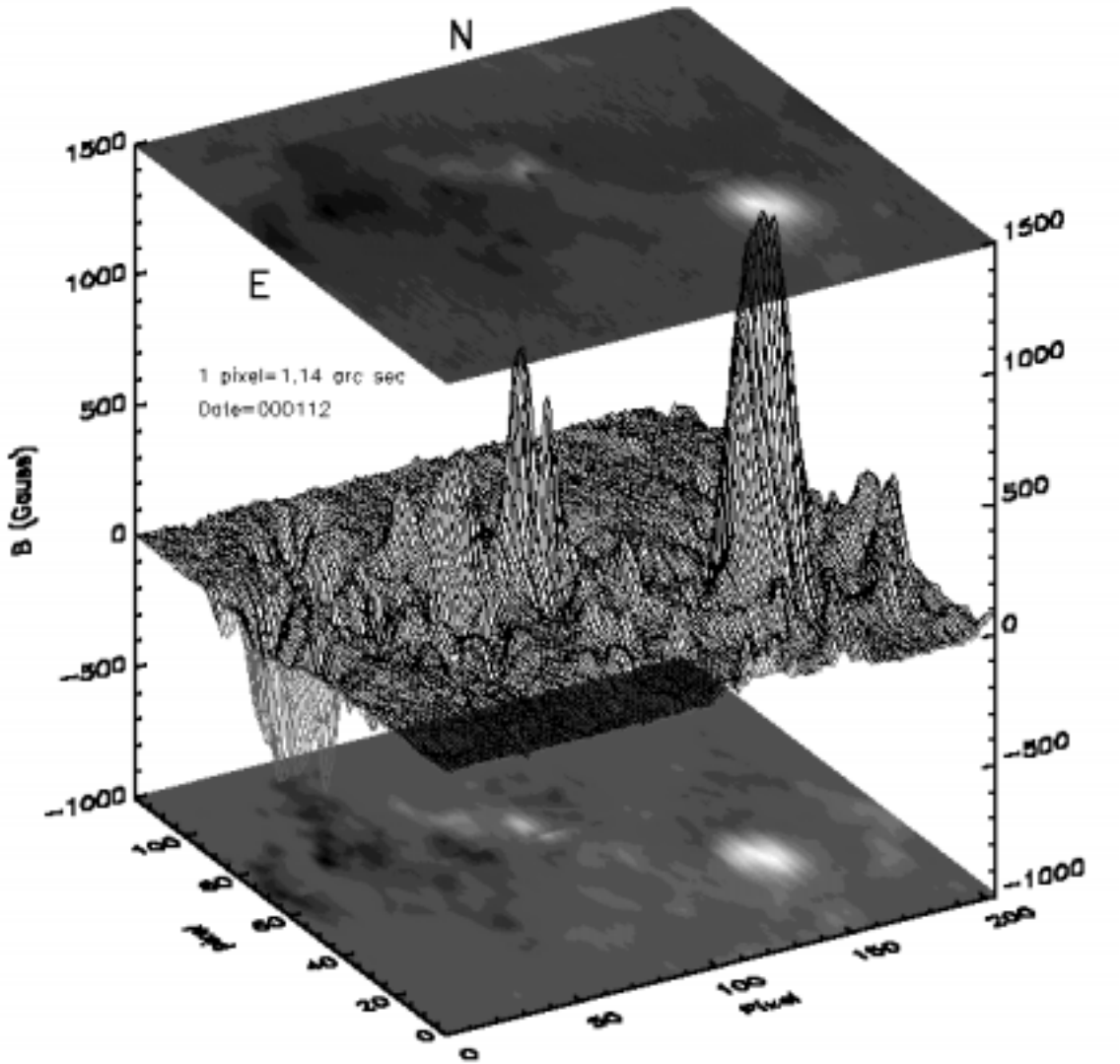

SiI
HeI
=>
<=
N
E

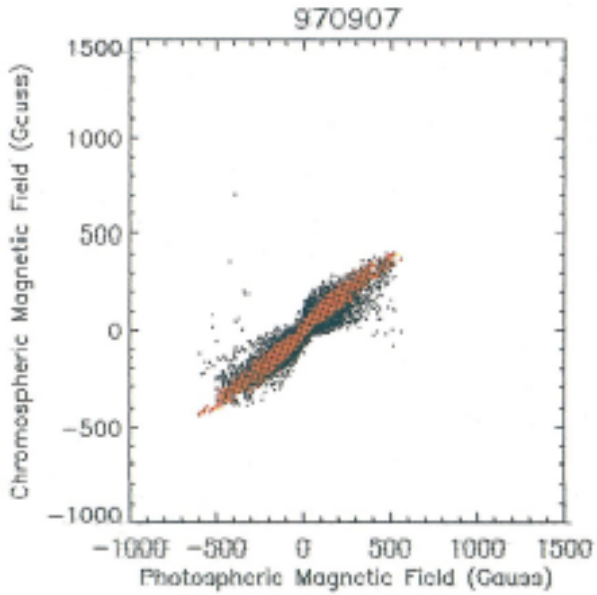
- The Slope of the scatter plot between the Si I and He I magnetograms are 0.5 and 0.76 in emerging flux and larger active region respectively.
- Kitt peak chromospheric and photospheric magnetograms show 0.89 and 0.9 for the same active regions.

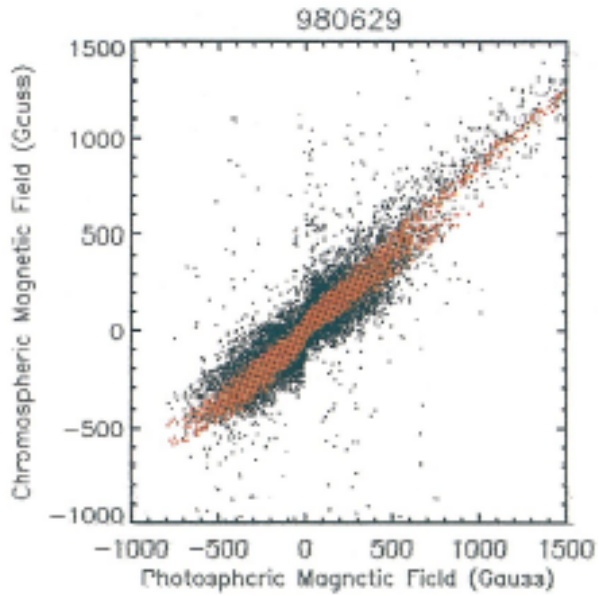
$\Rightarrow$Magnetic field spreads-out faster near the transition region heights.

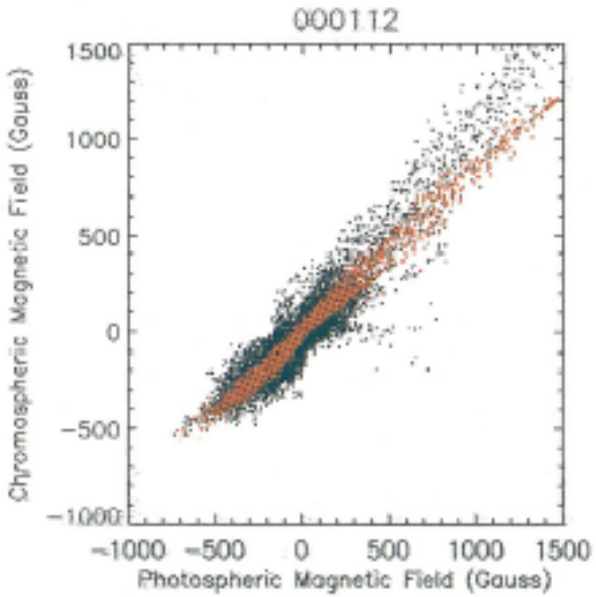
Up-flow regions are located near the neutral lines.

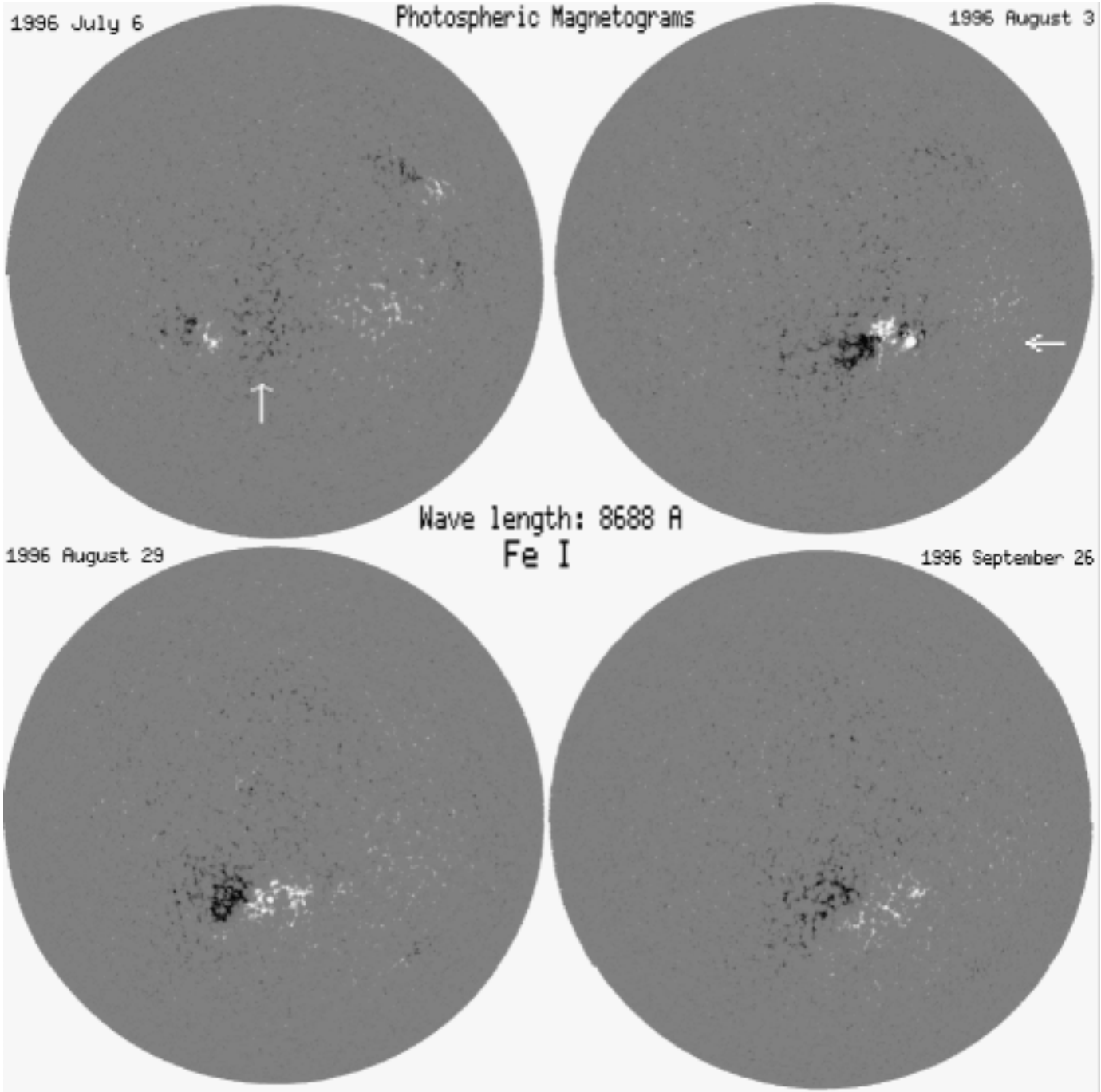
Debi Prasad, C., Sakurai, T., Venkatakrishnan, P., Ap. J., 560, 439, (2001)

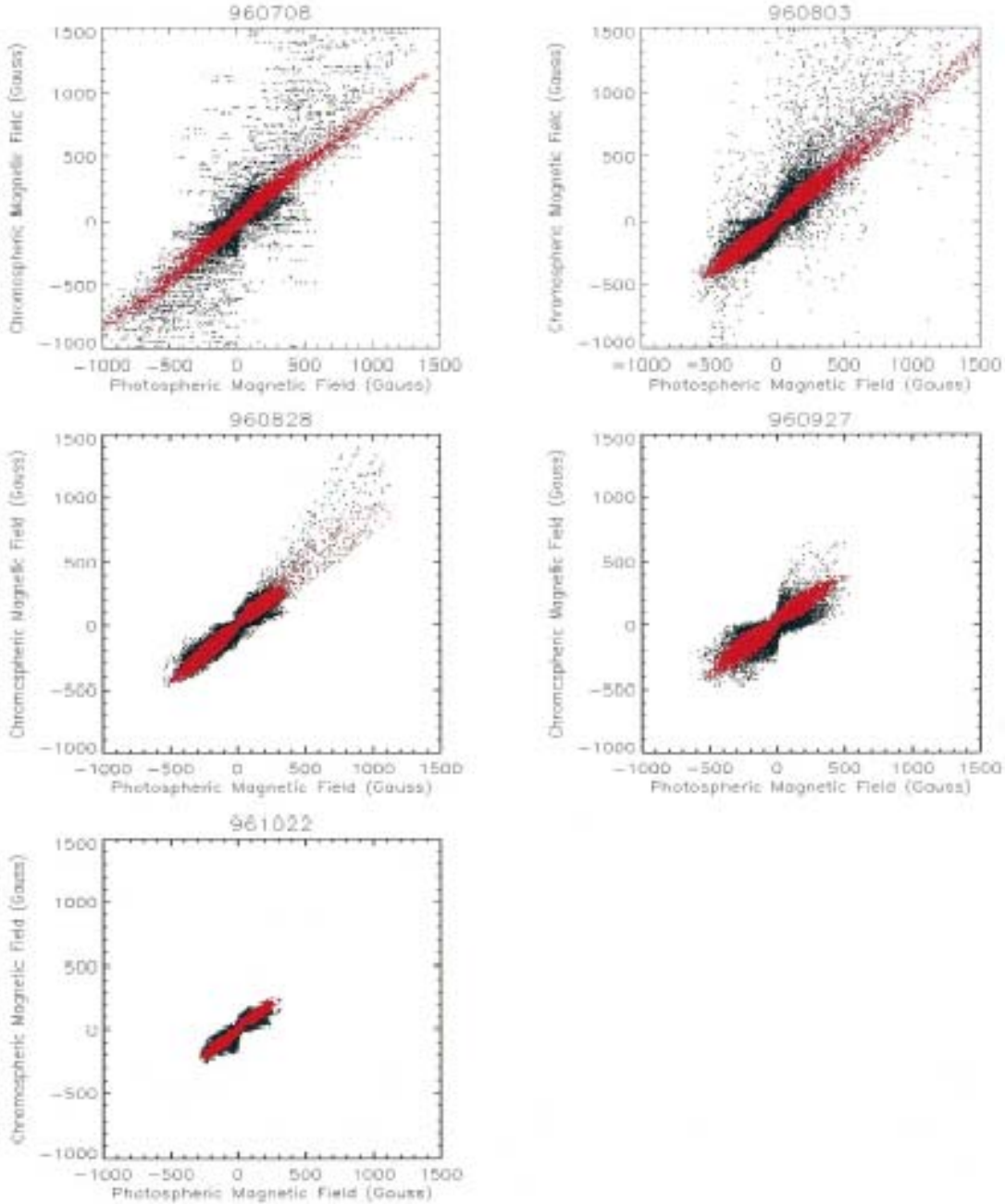



970907
Chromospheric Magnetic Field (Gauss)
Photospheric Magnetic Field (Gauss)
1500
1000
500
0
−500
−1000
−1000 −500 0 500 1000 1500


980629
Chromospheric Magnetic Field (Gauss)
Photospheric Magnetic Field (Gauss)
1500
1000
500
0
−500
−1000
−1000 −500 0 500 1000 1500


000112
Chromospheric Magnetic Field (Gauss)
Photospheric Magnetic Field (Gauss)
1500
1000
500
0
−500
−1000
−1000 −500 0 500 1000 1500

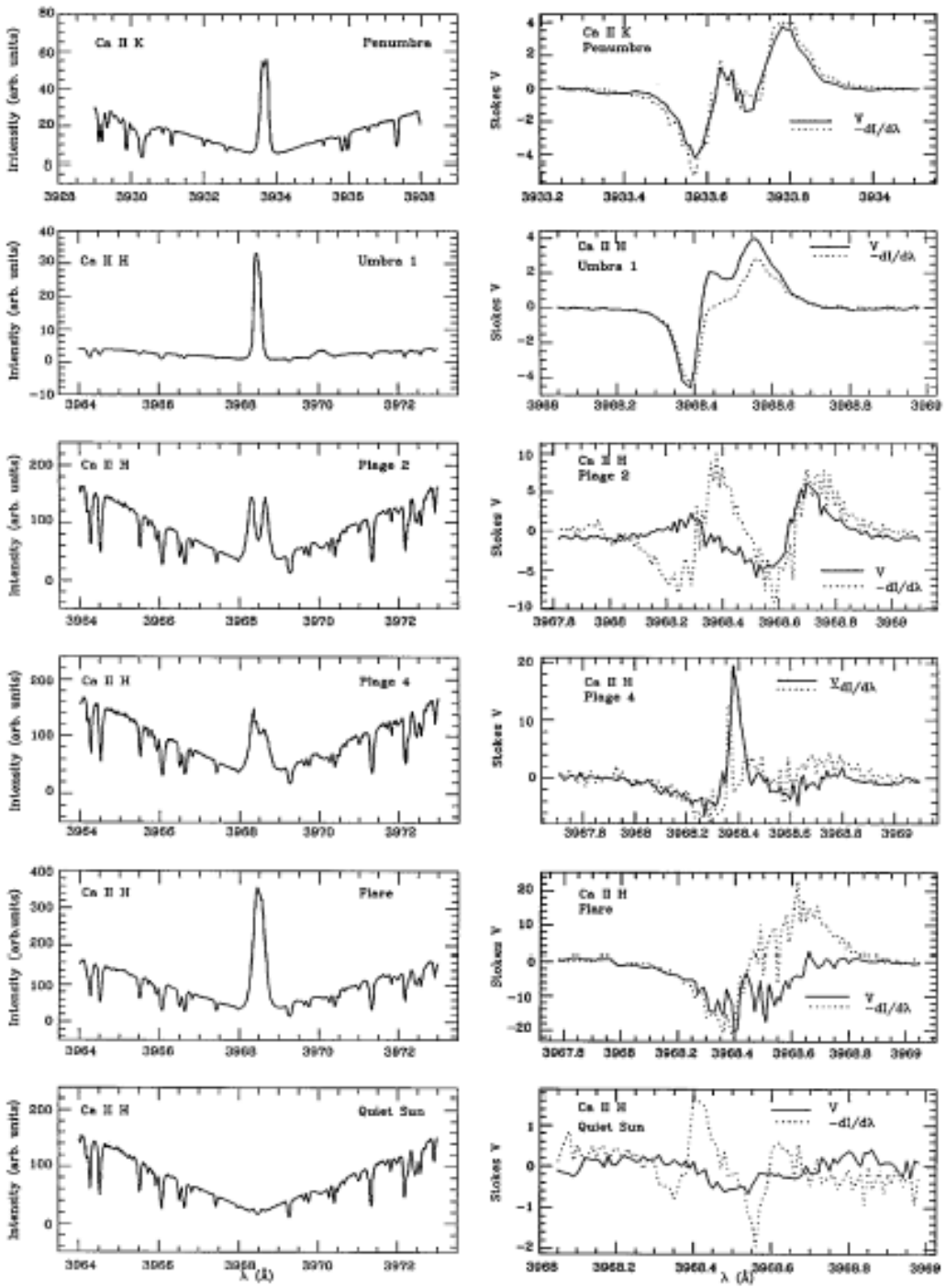

Photospheric Magnetograms
1996 July 6
1996 August 3
Wave length: 8688 A
Fe I
1996 August 29
1996 September 26


960708
960803
960828
960927
961022
Chromospheric Magnetic Field (Gauss)
Photospheric Magnetic Field (Gauss)
1500
1000
500
0
−500
−1000

Ca II 8542 Å (NSO/KP)

- The extrapolated and observed field are similar within ± 500 G. Many times the observed field is more spread-out.
- Beyond 500 G the observed chromospheric field is higher.
- As the active region evolves the chromospheric fields tends to become more like potential field configuration.

Martinez Pillet, V, et al., 1990, ApJ, 361, L81. ⇒

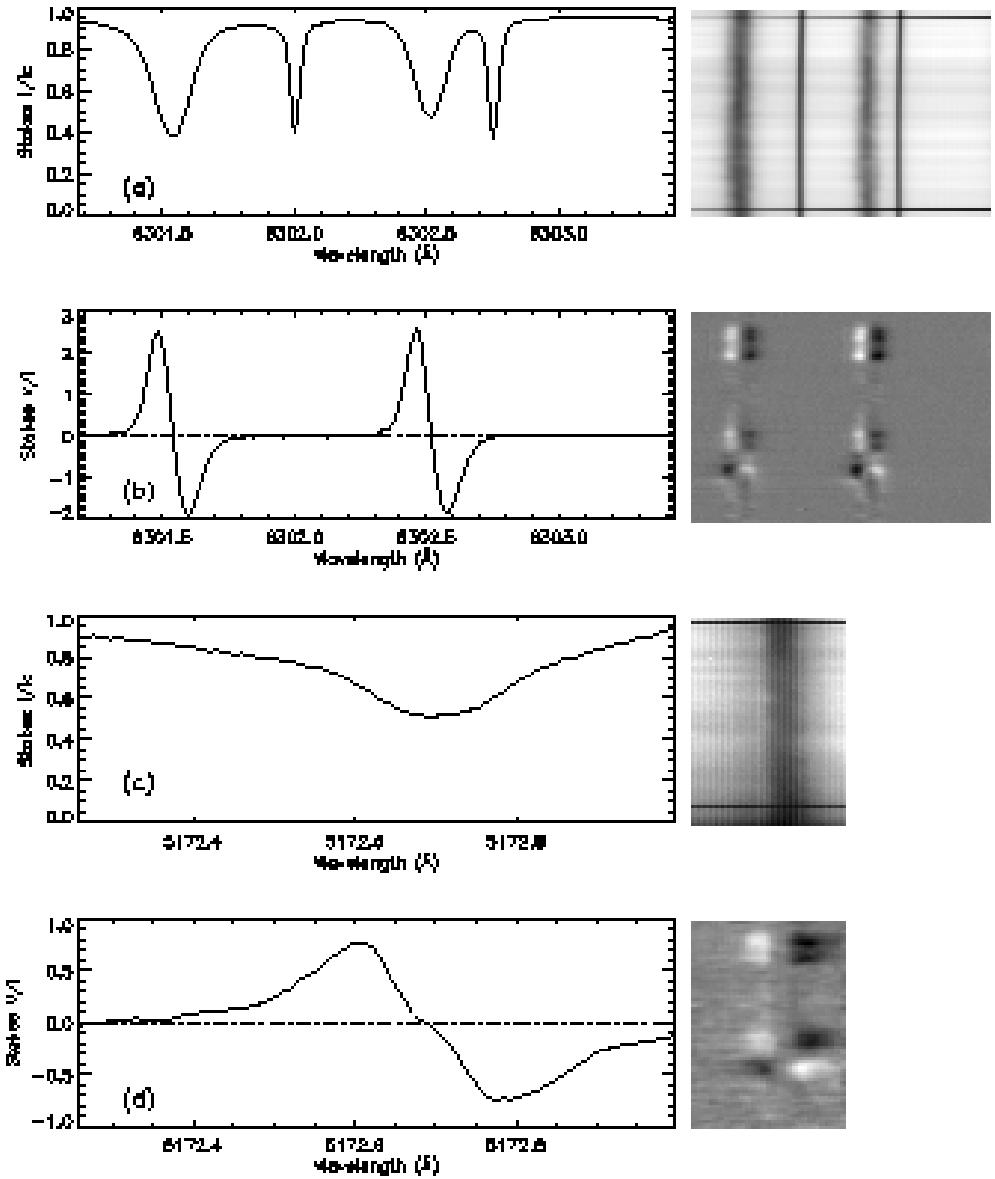


Similar Effects are observed with Ca II 8542 Å Stokes-V profiles. => multi-component chromosphere.

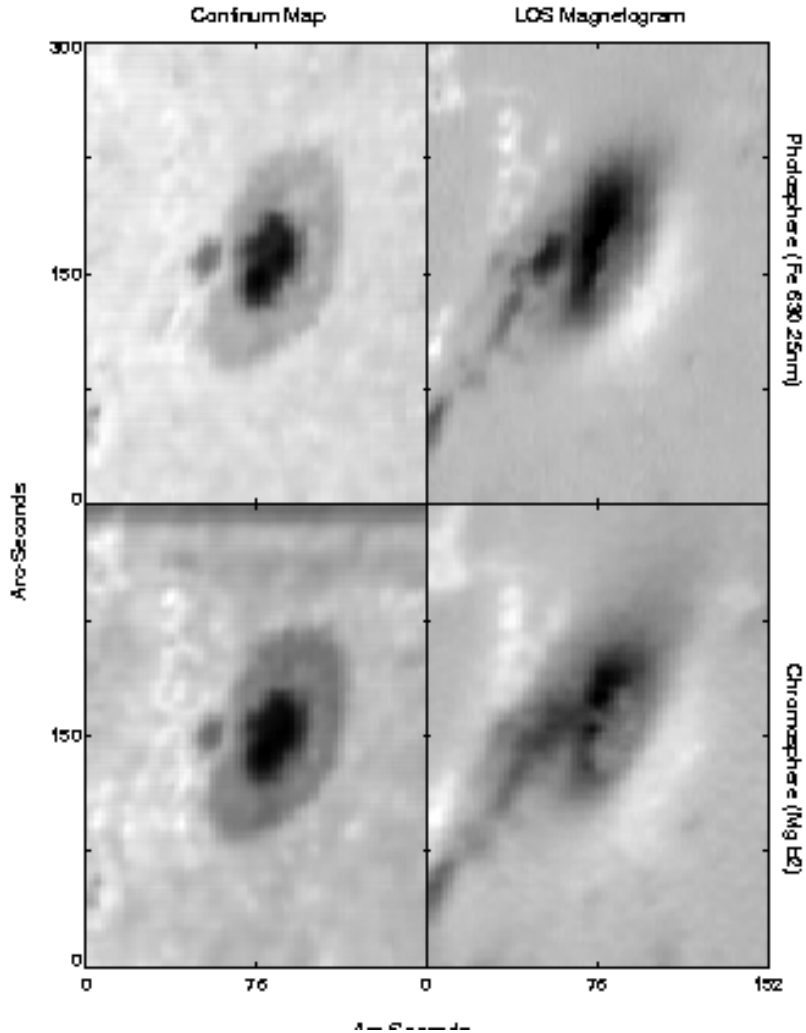
Scocas-Navarro et al, ApJ, 544, L141 (2000)

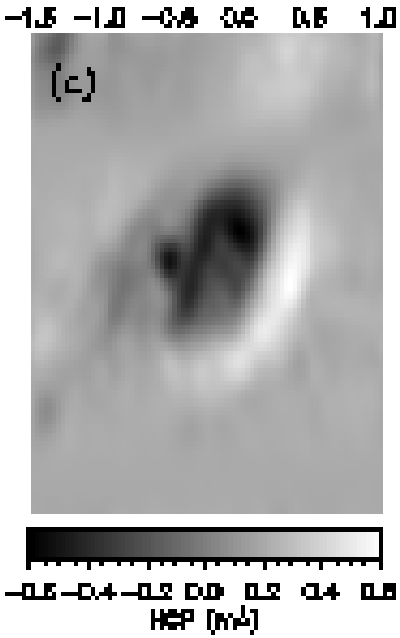
1999 January NSO/SP Observations

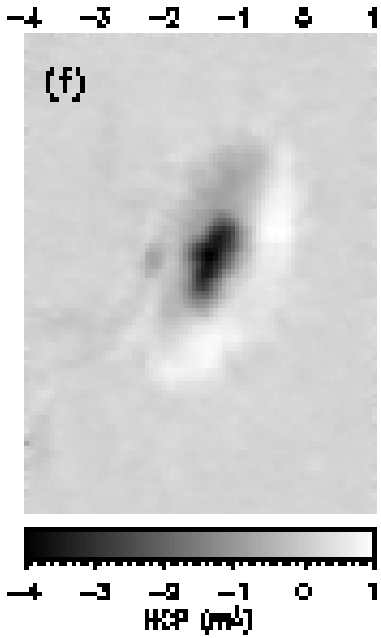
Gosain, S., Debi Prasad, 2002, Sol. Phy. (Sub).



The Mgb2 line is low chromosphere.

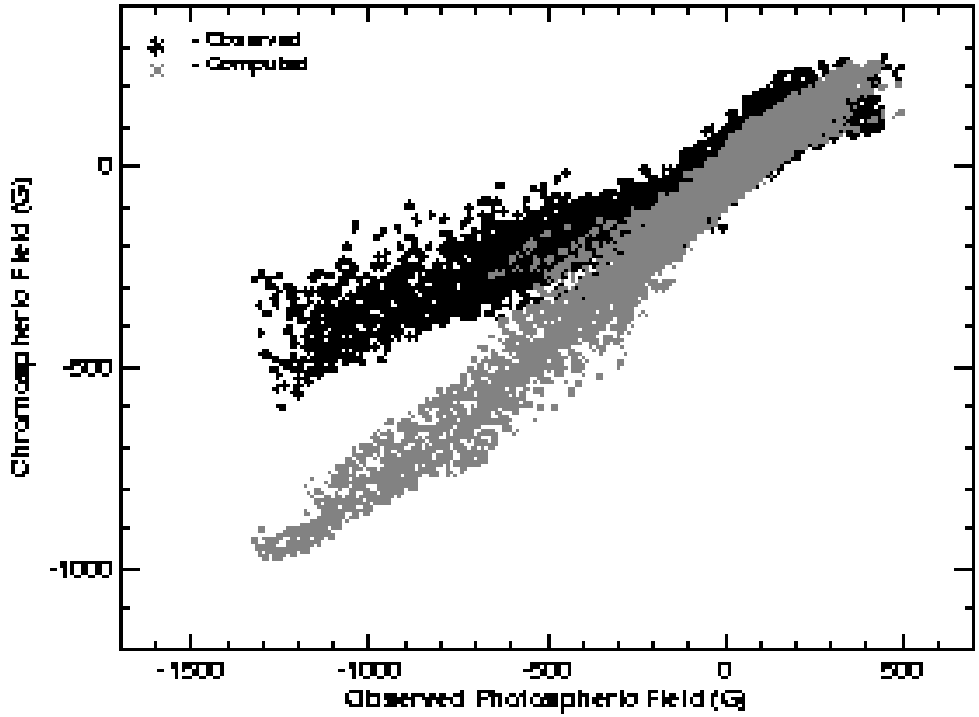


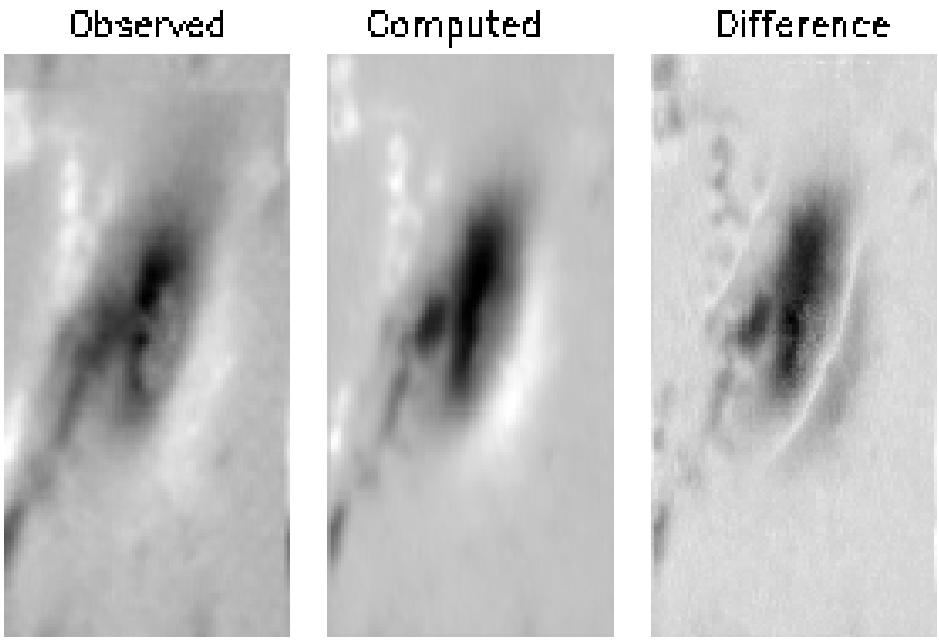




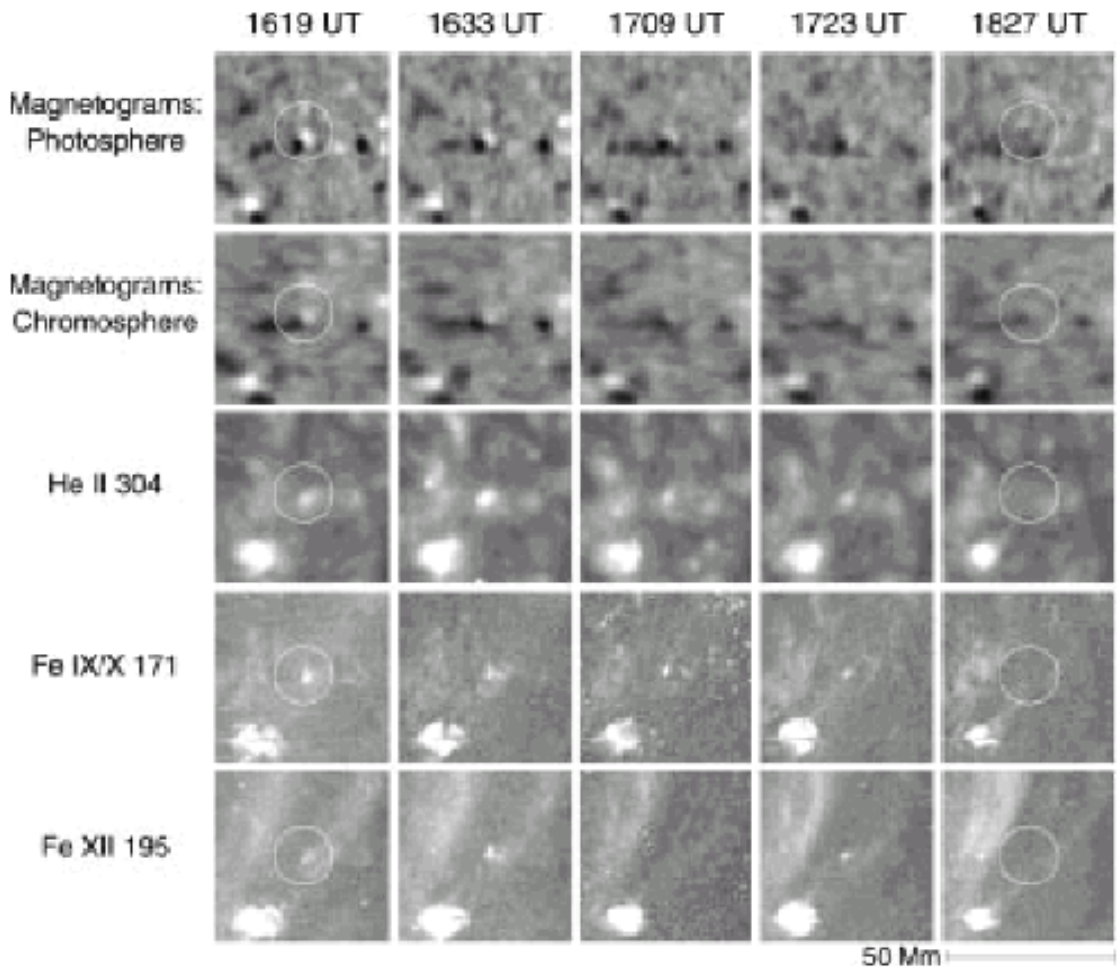
$$N = \int_{\delta\lambda} V(\lambda) d\lambda$$

Potential field do not match the observations beyond 500G.





Dynamic Chromosphere



$\Rightarrow$ Temporal Differences

K. Harvey, Jones, Schrijver, Penn (1999)

Summary

- **Few measurements using the Full Stoke Polarimetry are used to derive the field configuration above photosphere (~ 100 – 150 km) in the line forming region.**
- **Multi height measurements show complex structure including the reverse polarity regions.**
- **The strong field (beyond 500 G) are not consistent with the extrapolated photospheric values.**

Summary

- **Near transition region (He 10830 Å layer) the field diverges faster compared to upper chromosphere (CaII 8542 Å layer).**
- **The Mgb2 line, originating from lower chromosphere also show the canopy-like structure in net-circular-polarization maps.**
- ***Measurements are made with few lines at a time, it may be useful to observe with few selected lines simultaneously.***

Future

- **Vector measurements using the Ca II 8542 Line.**
- **Dynamical effects.**
- **Simultaneous Photospheric and Chromospheric field.**
- **SUMI like instruments (as Solar-b ahs one wavelength) for higher layers along with the analysis technique. ⇔ This needs ground based support for photospheric and chromospheric observations.**
- **DST, GREGOR, ATST and Solar-C.**
- **This decade will witness the chromospheric magnetic activity !!!**

The World of Debi Prasad Choudhary

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MS-M.Phil Kurukshetra University 79-80

Max-Planck Institute 90-91, 02

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National Solar Observatory
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Japanese National
Solar Observatory 94

NASA/MSFC 98-99,03

Observatory of Besanson 89

Observatory of Rome 02

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